WATER RESOURCES REPORT 13

WATER POSSIBILITIES FROM THE GLACIAL DRIFT OF CARROLL COUNTY

BY

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MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES

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MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES ROLLA, MO.
William C. Hayes, State Geologist and Director

WATER POSSIBILITIES FROM THE GLACIAL DRIFT OF CARROLL COUNTY

A special study of groundwater by the Missouri Geological Survey and Water Resources was made possible at the 1955 session of the Missouri Legislature. With the approval of the Governor, money was appropriated from the Missouri Post War Surplus Reserve Fund.

Since nearly two-thirds of the counties located north of the Missouri River are deficient in water supplies, much of the effort of this special study is being directed toward the problems of this area.

It has been shown that a program of test drilling can locate new reserves of groundwater. Potential areas are being tested so that additional supplies will be available for domestic, irrigation, industrial and municipal needs.

The most favorable areas are in the sand and gravel filled channels and valleys of pre-glacial and inter-glacial streams. Since these buried valleys do not conform to present day drainage patterns, a systematic program of test drilling is a principal means of locating the channels and mapping their extent. Such glacial deposits have proved to be excellent sources of groundwater.

QUALITY OF WATER FROM ROCK WELLS

The water from the consolidated rock formations which underlie Carroll County is, for the most part, mineralized. The following are analyses from water wells and oil tests.

CONSTITUENTS	IN PARTS PER MILLION				
	A	B	C	D	E
Turbidity	clear	5	turbid	sediment	sediment
Odor	none	none		none	none
pH		8.0		8.75	8.95
Alkalinity ($CaCO_3$)	455.0	750.5	285.5	620.5	815.5
Phenolpthalein		88.0		70.0	124.0
Methyl Orange		662.5		550.5	691.5
Carbonate (CO_3)	0.0	52.8	5.6	42.0	74.4
Bicarbonate (HCO_3)	554.9	808.3	342.4	671.6	843.6
Silica (SiO_2)	6.4	4.0	16.4	8.0	15.7
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	0.26*	0.3	1.20[a]	3.7	4.7
Calcium (Ca)	331.3	11.3	47.1	4.7	3.6
Magnesium (Mg)	97.5	6.0	14.6	2.9	2.3

CONSTITUENTS	IN PARTS PER MILLION				
	A	B	C	D	E
Sodium (Na) & Potassium (K) as Na	242.6.	517.8	91.3	762.1	758.9
Total Manganese (Mn)	0.10	0.03	0.03		
Total Iron (Fe)		0.78		0.08	0.16
Dissolved Iron	0.10	0.02			
Precipitated Iron		0.76			
Sulfate (SO_4)	1146.2	1.1	30.0	254.1	48.2
Chloride (Cl)	66.5	323.0	17.9	500.6	500.6
Nitrate (NO_3)	27.67	0.3			
Fluoride (F)	1.15	1.4	0.30		
Total Suspended Matter		12.			
Total Dissolved Solids	2584.0	1351.	451.0	1917.	1892.
Total Hardness	1228.0	52.9	177.6	23.6	18.5
Carbonate Hardness	455.0	52.9	177.6	620.5	815.5
Non-carbonate Hardness		0.0		0.0	0.0
Percent of Alkalies	30	96	53	99	99
*Al_2O_3					
[a]Al_2O_3 & Fe_2O_3					

A. Owner: Frank Cape, SW¼ SE¼ sec. 9, T. 55 N., R. 25 W. Total depth 411 feet. Ten gallons per minute, 190 feet drawdown. Static water level 15 feet. Analyzed July 15, 1935 by R. T. Rolufs.

B. Owner: Clifton Davies, SE¼ SE¼ sec. 14, T. 55 N., R. 25 W. Total depth 260 feet. Sample from pump May 8, 1957. Temperature of the water 59° F., of the air 83° F. Analyst: M. E. Phillips.

C. Owner: Loomis, Jordon, Reynolds & Browning. Lyman Rea Farm, SW¼ NW¼ sec. 36, T. 55 N., R. 25 W. Bottomed in Ardmore of the Pennsylvanian System at a depth of 330 feet. Water sample from the Henrietta formation of the Pennsylvanian System at a depth of 155 feet. Analyzed July 29, 1939 by R. T. Rolufs.

D. Owner: Missouri Blue Hill Oil Co. W. O'Roark farm, SW¼ SE¼ sec. 21, T. 55 N., R. 24 W. Bottomed in the Eminence formation of the Cambrian System at a depth of 2059 feet. Sampled June 25, 1951 from the Cherokee of the Pennsylvanian System at a depth of 530 to 550 feet. Analyst M. E. Phillips.

CONSTITUENTS	IN PARTS PER MILLION				
	F	G	H	I	J
Turbidity	Ferric	Ferric	Slight	Ferric	Slight
Odor	oily	none	none	none	musty
pH	6.9	7.6	8.75	7.85	
Alkalinity ($CaCO_3$)	272.0	197.5	505.0	200.0	569.1
Phenolpthalein	0.0	0.0	64.0	0.0	
Methyl Orange	272.0	197.5	441.0	200.0	
Carbonate (CO_3)	0.0	0.0	38.4	0.0	12.1
Bicarbonate (HCO_3)	331.8	241.0	538.0	244.0	694.0
Silica (SiO_2)	6.0	4.0	6.7	3.7	4.4

CONSTITUENTS	IN PARTS PER MILLION				
	F	G	H	I	J
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	7.3	0.7	2.0	4.3	0.30*
Calcium (Ca)	397.3	226.4	10.5	306.0	43.0
Magnesium (Mg)	110.8	86.4	20.6	161.5	12.8
Sodium (Na) & Potassium (K) as Na	726.3	1157.4	1946.6	3141.8	527.2
Total Manganese (Mn)					0.05
Total Iron (Fe)	43.8	8.8	1.1	6.7	1.37
Dissolved Iron					0.07
Precipitated Iron					1.30
Sulfate (SO_4)	149.4	317.3	614.2	1276.8	299.3
Chloride (Cl)	1642.	2116.	2243.6	4693.	311.9
Nitrate (NO_3)					1.28
Fluoride (F)					1.50
Total Suspended Matter					
Total Dissolved Solids	4015.	4644.	5276.	10291.	1584.0
Total Hardness	1448.2	921.0	111.0	1428.9	160.0
Carbonate Hardness	272.0	197.5	505.0	200.0	160.0
Non-carbonate Hardness	1176.2	723.5	0.0	1228.9	
Percent of Alkalies	52	73	87	83	88

*Al_2O_3

E. As above. Water sample from 570 feet. Thirty-three gallons per minute, 200 feet of drawdown. Static water level 250 feet. Bailer sample collected June 16,, 1951. Snalyst: M. E. Phillips.

F. As above. Water sample from the top of the Devonian System at 925 feet. Collected July 23, 1951. Analyst: M. E. Phillips.

G. As above. Bailer sample from 945 foot depth. Sampled July 25, 1951. Analyst: M. E. Phillips.

H. As above. Casing set at 925 feet. Sampled by bailer with a hole depth of 1250 feet near base of Kimmswick formation, Ordovician System. Yield 24.7 gallons per minute with 95 feet of drawdown. Static water level 294 feet. Sampled August 4, 1951. Analyst: M. E. Phillips.

I. As above. Hole depth 1335 feet, St. Peter formation, Ordovician System. Two inch tubing with a packer giving complete shut-off of water above 1144 feet. Sampled August 14, 1951. Analyst: M. E. Phillips.

J. Owner: Anthony Key, SW¼ SE¼ sec. 24, T. 55 N., R. 24 W. Total depth 488 feet. "Big flow." Static water level 18 feet. Analyzed August 15, 1935 by R. T. Rolufs.

CONSTITUENTS	IN PARTS PER MILLION				
	K	L	M	N	O
Turbidity	220	slight	slight	turbid	slight
Odor	none	none	none	none	none
pH	7.5				

CONSTITUENTS	IN PARTS PER MILLION				
	K	L	M	N	O
Alkalinity ($CaCO_3$)	614.0	118.6	210.0	258.5	131.0
Phenolpthalein	0.0				
Methyl Orange	614.0				
Carbonate (CO_3)	0.0	0.0	0.0	0.0	0.0
Bicarbonate (HCO_3)	749.1	144.6	256.1	315.3	159.7
Silica (SiO_2)	5.5	4.8	11.2	13.6	14.0
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	1.0	0.26*	0.66*	0.51*	0.66*
Calcium (Ca)	132.2	233.1	139.1	45.2	188.6
Magnesium (Mg)	69.6	84.5	14.9	10.0	49.8
Sodium (Na) & Potassium (K) as Na	1697.2	275.4	47.2	67.0	169.2
Total Manganese (Mn)	0.02	0.10	0.14	0.40	0.12
Total Iron (Fe)	7.92	2.30	1.10		1.60
Dissolved Iron	0.08	0.10	0.10	0.20	0.10
Precipitated Iron	7.84	2.20	1.00	12.10	1.50
Sulfate (SO_4)	581.1	275.9	116.2	42.0	261.7
Chloride (Cl)	2108.	477.1	56.9	6.4	306.4
Nitrate (NO_3)	0.0	442.8	1180.8	0.0	328.0
Fluoride (F)		0.30	0.30	0.35	0.25
Total Suspended Matter	7.	48.0	43.0	55.4	14.4
Total Dissolved Solids	4983.	2434.0	847.0	385.0	1824.0
Total Hardness	616.5	929.2	408.8	154.0	675.7
Carbonate Hardness	614.0	118.6	210.0	154.0	131.0
Non-carbonate Hardness	2.5				
Percent of Alkalies	86	39	20	49	35

*Al_2O_3

K. Owner: Tina School R-2, SW¼ SW¼ sec. 10, T. 55 N., R. 23 W. Total depth 545 feet bottomed in Burlington-Keokuk of the Mississippian System. Twenty gallons per minute. Static water level 100 feet. Water sampled from the Mississippian System June 3, 1954. Analyst: M. E. Phillips.

L. Owner: John S. Shirley, SW¼ SE¼ SE¼ sec. 12, T. 54 N., R. 25 W. Total depth 500 feet. Ten gallons per minute, 390 feet of drawdown. Static water level 16 feet. Analyzed July 15, 1935 by R. T. Rolufs.

M. Owner: W. O. Pitts, SE¼ SW¼ SW¼ sec. 7, T. 54 N., R. 24 W. Total depth 450 feet. Two gallons per minute, 280 feet of drawdown. Static water level 40 feet. Analyzed July 15, 1935 by R. T. Rolufs.

N. Owner: Clem Jenkins, SE¼ NE¼ sec. 12, T. 54 N., R. 22 W. Total depth 118 feet. Analyzed June 21, 1935 by R. T. Rolufs.

O. Owner: Frank Lyons, SE¼ SE¼ NW¼ sec. 12, T. 53 N., R. 25 W. Total depth 437 feet. Ten gallons per minute. Static water level 14 feet. Analyzed July 15, 1935 by R. T. Rolufs.

CONSTITUENTS	IN PARTS PER MILLION				
	P	Q	R	S	T
Turbidity	Turbid	Turbid	Slight		50
Odor	None	None	Mouldy		None
pH					7.4
Alkalinity ($CaCO_3$)	486.4	482.2	185.2		392.5
Phenolpthalein					8.0
Methyl Orange					384.5
Carbonate (CO_3)	21.6	46.0	0.0	0.0	4.8
Bicarbonate (HCO_3)	593.2	588.0	225.8	275.4	469.1
Silica (SiO_2)	5.2	2.4	6.0	70.6	6.5
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	0.66*	0.89*	0.59*	19.6[a]	
Calcium (Ca)	70.5	1.4	224.5	104.8	321.8
Magnesium (Mg)	70.1	1.6	61.7	7.9	158.0
Sodium (Na) & Potassium (K) as Na	2848.2	660.9	82.3	1066.2	3323.6
Total Manganese (Mn)		0.06	0.09		0.05
Total Iron (Fe)	5.06	18.80	2.15		3.44
Dissolved Iron	0.10	0.50	0.15		0.21
Precipitated Iron	4.96	18.30	2.00		3.23
Sulfate (SO_4)	566.8	0.0	144.6	0.0	1073.3
Chloride (Cl)	3685.4	699.7	132.6	3181.9	5000.0
Nitrate (NO_3)	0.0	0.25	520.94	0.0	0.07
Fluoride (F)		1.20	0.70		1.4
Total Suspended Matter	45.2	73.6	17.4		
Total Dissolved Solids	7731.0	1747.0	1632.0	3578.4	10277.
Total Hardness	463.7	10.1	714.2	294.4	1453.8
Carbonate Hardness	463.7	10.1	185.2		392.5
Non-carbonate Hardness					1061.3
Percent of Alkalies	93	99	18	89	83

*Al_2O_3
[a]Al_2O_3 & Fe_2O_3

P. Owner: Jade Donaldson, SE¼ NE¼ SE¼ sec. 20, T. 53 N., R. 24 W. Total depth 365 feet. Ten gallons per minute, static water level 60 feet. Water sample probably from the Cherokee of the Pennsylvanian System. Analyzed October 20, 1934 by R. T. Rolufs.

Q. Owner: Northwestern Mutual Insurance Company Farm, SW¼ SE¼ sec. 12, T. 53 N., R. 24 W. Total depth 400 or 460 feet. Analyzed July 1, 1935 by R. T. Rolufs.

R. Owner: W. H. Graham, SE¼ NW¼ sec. 7, T. 53 N., R. 23 W. Total depth 530 feet. "Nearly dry hole." Analyzed July 1, 1935 by R. T. Rolufs.

S. Owner: S. H. Minus, SW¼ NE¼ SW¼ sec. 32, T. 53 N., R. 23 W. Total depth 241 feet. Flowing well at time of completion.

T. Owner: Rudolph Kruse, NE¼ SE¼ SW¼ sec. 16, T. 53 N., R. 23 W. Total depth 495 feet. Sample collected from reservoir May 8, 1957. Analyst: M. E. Phillips.

CONSTITUENTS	IN PARTS PER MILLION				
	U	V	W	X	Xa
Turbidity	Slight	Turbid		Turbid	Turbid
Odor	Musty				
pH					
Alkalinity ($CaCO_3$)	299.2	358.6		653.7	651.4
Phenolpthalein					
Methyl Orange					
Carbonate (CO_3)	0.0	0.0		0.0	2.8
Bicarbonate (HCO_3)	364.9	437.3		797.2	791.6
Silica ($SiO2$)	6.0	7.2		8.0	9.6
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	0.00*	11.20[a]	202.5	2.00[a]	0.80[a]
Calcium (Ca)	299.1	843.0	384.5	40.0	23.3
Magnesium (Mg)	124.5	253.5	99.4	14.4	10.9
Sodium (Na) & Potassium (K) as Na	1664.1	4817.6	3323.0	303.1	333.6
Total Manganese (Mn)	0.14				
Total Iron (Fe)	4.10				
Dissolved Iron	0.30				
Precipitated Iron	3.80				
Sulfate (SO_4)	519.1	1407.9	408.0	18.1	18.3
Chloride (Cl)	2935.8	7971.8	5077.9	114.3	123.2
Nitrate (NO_3)	0.0				
Fluoride (F)	1.20			0.45	0.76
Total Suspended Matter	52.6				
Total Dissolved Solids	6587.0	17475.0		904.0	920.0
Total Hardness	1258.2	3146.9		159.0	102.9
Carbonate Hardness	299.2	358.6		159.0	102.9
Non-carbonate Hardness					
Percent of Alkalies	74	77	84	81	88

[a] Al_2O_3 & Fe_2O_3
*Al_2O_3

U. Owner: Errie Raasch, NW¼ SE¼ sec. 29, T. 53 N., R. 21 W. Total depth 292 feet. Analyzed June 21, 1935 by R. T. Rolufs.

V. Owner: Mary Schindheim, SW¼ SW¼ NW¼ sec. 16, T. 53 N., R. 21 W. Total depth 244 feet bottomed in the Burlington-Keokuk formation of the Mississippian System. Analyzed August 19, 1941 by R. T. Rolufs.

W. Owner: Daniel Heins, SE¼ NW¼ NW¼ sec. 3, T. 52 N., R. 23 W. Total depth 188 feet. Well flows. Analyzed July 16, 1903 by State Board of Health.

X. Owner: Evert Williams et al, Tom Hiatt farm, NW¼ SE¼ SE¼ sec. 7, T. 52 N., R. 22 W. Bottomed in Burlington-Keokuk formation of the Mississippian System at a total depth of 298 feet. Sample from upper part of the Cherokee of the Pennsylvanian System at a depth of 45 to 50 feet. Analyzed August 6, 1940 by R. T. Rolufs.

Xa. As above. Sample from upper Burlington-Keokuk formation at a depth of 210 feet. Analyzed August 6, 1940 by R. T. Rolufs.

CONSTITUENTS	IN PARTS PER MILLION		
	Y	Ya	Z
Turbidity	Sediment	Sediment	Sediment
Odor	Oily	None	Oily
pH	7.5	7.9	7.6
Alkalinity ($CaCO_3$)	286.5	105.5	288.5
Phenolpthalein			
Methyl Orange			
Carbonate (CO_3)	0.0	0.0	0.0
Bicarbonate (HCO_3)	349.5	128.7	352.0
Silica (SiO_2)	11.3	6.3	11.0
Oxides (Al_2O_3, Fe_2O_3 TiO_2, etc.)	4.0	2.7	4.3
Calcium (Ca)	520.2	457.9	621.7
Magnesium (Mg)	275.7	226.1	301.7
Sodium (Na) & Potassium (K) as Na	4837.9	4784.8	4965.8
Total Manganese (Mn)			
Total Iron (Fe)	15.0	1.05	75.7
Dissolved Iron			
Precipitated Iron			
Sulfate (SO_4)	1287.7	1162.6	1446.8
Chloride (Cl)	7635.0	7765.0	8250.0
Nitrate (NO_3)			
Fluoride (F)			
Total Suspended Matter			
Total Dissolved Solids	15400.	15066.	16911.
Total Hardness	2433.7	2074.0	2794.2
Carbonate Hardness			
Non-carbonate Hardness			
Percent of Alkalies	81	83	79

Y. Owner: McVicar, Rood and Marion; Carlos Bricken farm, NE¼ NE¼ sec. 8, T. 52 N., R. 22 W. Bottomed in Devonian System at a depth of 590 feet. Sample from 452 feet, Burlington-Keokuk formation of the Mississippian System. Sampled July 16, 1948. Analyst: M. E. Phillips.

Ya. As above. Sample from Devonian System at 590 feet. Sampled July 28, 1948. Analyst: M. E. Phillips.

Z. Owner: McVicar, Rood and Marion; Rimer farm, SW¼ SW¼ SE¼ sec. 9, T. 52 N., R. 22 W. Total depth 325 feet, bottomed in Burlington-Keokuk formation. Sampled August 8, 1948 from 325 foot depth. Analyst: M. E. Phillips.

Referring to Plate 1, it will be noted that a large area of Carroll County is unfavorably located to obtain water from glacial drift. Wells drilled into the consolidated rock of the Pennsylvanian System to moderate depths may possibly obtain limited yields of water of marginal quality. The water from "rock" wells in all probabilities will become more

mineralized with increased depth of drilling.

QUALITY AND QUANTITY OF WATER FROM STREAMS

The following analyses is from a water sample taken from the Wakenda Creek, sec. 16, T. 52 N., R. 22 W. The stream when sampled at 9:15 a.m. September 20, 1955 was muddy from a night's rain of 0.75 inches. The water temperature was 72° F., of the air 73° F.

CONSTITUENTS	IN PARTS PER MILLION
Turbidity	600.
Odor	None
pH	7.2
Alkalinity ($CaCO_3$)	153.5
Phenolpthalein	0.0
Methyl Orange	153.5
Carbonate (CO_3)	0.0
Bicarbonate (HCO_3)	187.3
Silica (SiO_2)	19.0
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	7.5
Calcium (Ca)	47.7
Magnesium (Mg)	12.0
Sodium (Na) & Potassium (K) as Na	17.7
Total Manganese (Mn)	0.00
Total Iron (Fe)	10.96
Dissolved Iron	1.48
Precipitated Iron	9.48
Sulfate (SO_4)	23.5
Chloride (Cl)	6.0
Nitrate (NO_3)	1.4
Fluoride (F)	0.7
Total Suspended Matter	276.
Total Dissolved Solids	253.
Total Hardness	168.5
Carbonate Hardness	153.5
Non-carbonate Hardness	15.0
Percent of Alkalies	19

Of the streams flowing within or bordering Carroll County, only the Missouri River has flow during low water adequate for irrigation.

The following are stream flow data from: Bolon, Harry C., Surface Waters of Missouri; Missouri Geological Survey and Water Resources, 2d ser., Vol. 34, pp. 219, 305 and 316.

Missouri River at Waverly

Location. -- Water-stage recorder, lat. 39° 12' 51", long. 93° 30'57", in sec. 14, T. 51 N., R. 24 W., at bridge on U. S. Highway 65 at Waverly. Datum of gage is 645.49 feet above mean sea level, datum of 1929. From

June 14, 1943 to September 15, 1944, wire-weight gage at same site and datum.

Drainage Area. -- 491, 200 square miles.

Records Available. -- March 1929 to September 1949.

Average Discharge. -- 20 years, 44,040 second-feet.*

Extremes. -- 1929-49: Maximum discharge, 347,000 second-feet April 24, 1944; maximum gage height, 25.14 feet June 24, 1947; minimum discharge about 1,700 second-feet January 9, 1940; minimum gage height, 0.4 foot (present datum) January 12, 1930.

Remarks. -- Records good 1940, 41, 49; excellent, 1942-48, except those for periods of ice effect, which are fair to good. Drainage basin above station contains many reservoirs with total usable capacity in excess of 27,640,000 acre-feet.

Cooperation. --Station maintained by U. S. Geological Survey in cooperation with Corps of Engineers. Gage-height record collected in cooperation with U. S. Weather Bureau.

*One second-foot equals 448.83 gallons per minute.

Wakenda Creek at Carrollton

Location. --Wire-weight gage, lat. 39° 21', long. 93° 30', in NE¼ SE¼ sec. 5, T. 52 N., R. 23 W., at bridge on U S. Highway 65 in Carrollton, half a mile downstream from Brush Creek and 14 miles upstream from mouth. Datum of gage is 641.17 feet above mean sea level, datum of 1929.

Drainage Area. --248 square miles.

Records Available. --March 1948 to September 1949.

Extremes. --1948-49: Maximum discharge 7,000 second-feet March 20, 1948 (gage height, 22.64 feet, from floodmark); minimum observed, 1.8 second-feet September 29, 1948 (gage-height, 6.05 feet).

Remarks. --Records poor.

Cooperation. --Station maintained by U. S. Geological Survey in cooperation with Corps of Engineers.

Grand River Near Sumner

Location. --Water-stage recorder, lat. 39° 38' 25", long. 93° 16' 25", in NE¼ sec. 29, T. 56 N , R. 21 W., at Chicago, Burlington & Quincy Railroad bridge, 2 miles southwest of Sumner and 2 ½ miles downstream from Locust Creek. Datum of gage is 630.87 feet above mean sea level, datum of 1929. Auxiliary staff gage 3¼ miles downstream. Datum of auxiliary gage is 631.00 feet above mean sea level, datum of 1929. From April 1, 1940 to August 4, 1942, the auxiliary gage was 4 miles downstream.

Drainage Area. --6,880 square miles.

Records Available. --April 1924 to September 1949.

Average Discharge. --25 years, 3,850 second-feet.

Extremes. --1924-49: Maximum discharge, 180,000 second-feet June 7, 8, 1947 (gage-height, 39.5 feet, from floodmark); minimum observed, 10 second-feet August 12, 1934.

Flood of July 9, 1909 reached a stage of 36.7 feet, from floodmark.

Remarks. --Records fair except those periods of ice effect, which are poor.

Cooperation. --Station maintained by U. S. Geological Survey in cooperation with Corps of Engineers.

QUALITY OF WATER FROM GLACIAL DRIFT

In general, the water from the glacial drift is high in total iron, total dissolved solids, and sulfates. The iron content in the water may cause staining of plumbing fixtures and laundry; however, relatively inexpensive water treatment for the iron will prevent this staining. For most types of irrigation, total dissolved solids should not exceed 2000 parts per million and total alkalies should not exceed 75 percent. Most people cannot tolerate water for drinking purposes which contains more than 1500 parts per million of chloride, or 2000 parts per million sulfate. Water with 300 parts per million of chloride taste salty to some people. Sulfates in excess of 500 parts per million may have a laxative effect when first used for drinking.

One of the samples of water as shown by the following analyses and several of water samples from "rock" wells contained excessive nitrates. The following is quoted from the article, The Public Health Significance of High Nitrate Waters As a Cause of Infant Cynosis and Methods of Control, Metzler, D. F., and Staltenberg, H. A., Trans. Kansas Acad. Scie. Vol. 53, No. 2, p. 194 and 205, 1950.

"The cyonosis of infants can be caused by the ingestion of nitrates in the water used for making the feeding formula. The nitrates are converted to nitrites and absorbed by the blood, where they destroy its oxygen-carrying properties. The blood becomes chocolate brown, the skin develops a blue color and death may result from oxygen starvation." "Nitrate concentrations exceeding 10 to 20 ppm of nitrate nitrogen are considered unsafe."

The following are thirteen water analyses from glacial drift wells.

CONSTITUENTS	IN PARTS PER MILLION				
	1	2	3	4	5
Turbidity	4	1.0	0.2	5	8
Odor	None	None	None		None
pH	7.6	7.2	7.2	7.0	7.5
Alkalinity ($CaCO_3$)	70.5	230.0	325.0	198.0	254.4
Phenolpthalein	8.0	0	0	0	0.0
Methyl Orange	62.5	230.0	325.0	198.0	254.5
Carbonate (CO_3)	4.8	0	0	0	0.0
Bicarbonate (HCO_3)	76.3	280.2	395.6	241.7	310.5
Silica (SiO_2)	4.0	22.0	20.0	14.0	3.4

CONSTITUENTS	IN PARTS PER MILLION				
	1	2	3	4	5
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	1.5				0.6
Calcium (Ca)	341.7	84.5	89.3	56.0	67.7
Magnesium (Mg)	109.5	20.6	19.7	10.2	17.1
Sodium (Na) & Potassium (K) as Na	229.8	93.9	102.4	30.7	62.2
Total Manganese (Mn)	0.03				0.04
Total Iron (Fe)	1.47	0.2	0.3	0.8	1.85
Dissolved Iron	0.08				0.06
Precipitated Iron	1.39				1.79
Sulfate (SO_4)	86.6	135.4	123.0	17.1	20.7
Chloride (Cl)	410.0	45.0	46.8	10.3	34.5
Nitrate (NO_3)	992.0	52.0	0.53	20.4	3.1
Fluoride (F)	0.1	0.5		0.2	0.1
Total Suspended Matter					2.
Total Dissolved Solids	2715.	598.0	665.0	316.0	375.
Total Hardness	1303.9	295.0	304.0	182.0	239.5
Carbonate Hardness	70.5	230.0	304.0	182.0	239.5
Non-carbonate Hardness	1233.4	65.0	0	0	0.0
Percent of Alkalies	28	41	42	27	36

1. Owner: Clifton Davies, SE¼ SE¼ sec. 14, T. 55 N., R. 25 W. Dug well 32 feet deep. Sample collected May 8, 1957 from the pump. Temperature of the water 58° F., of the air 83° F. Analyst: M. E. Phillips.

2. Owner: City of Hale. Well number 2, sampled February 25, 1947. Analyzed by Missouri Division of Health.

3. Owner: City of Hale. Sampled May 19, 1947. Analyzed by Missouri Division of Health.

4. Owner: City of Bosworth. "New well." Analyzed May 2, 1957 by Missouri Division of Health.

5. Owner: Norris Hensley, SE¼ SE¼ SE¼ NE¼ sec. 11, T. 53 N., R. 22 W. Drilled well 80 (?) feet deep. Sample from pump May 9, 1957. Temperature of the water 58° F., of the air 75° F. Analyst: M. E. Phillips.

CONSTITUENTS	IN PARTS PER MILLION				
	6	7	8	9	10
Turbidity	12	Slight	50.0	20.0	50.0
Odor	None	None			None
pH	7.55		6.9	7.0	
Alkalinity ($CaCO_3$)	264.5	241.7	303.0	301.0	302.0
Phenolpthalein	10.0		0	0	0
Methyl Orange	254.5		303.0	301.0	302.0
Carbonate (CO_3)	6.0	0.0	0		0
Bicarbonate (HCO_3)	310.5	294.7	369.8	366.9	367.7
Silica (SiO_2)	3.2	17.2	16.0	20.0	
Oxides (Al_2O_3, Fe_2O_3, TiO_2, etc.)	0.4	0.26*			2.0
Calcium (Ca)	66.5	71.7	121.4	117.9	110.5

CONSTITUENTS	IN PARTS PER MILLION				
	6	7	8	9	10
Magnesium (Mg)	16.9	13.1	26.0	25.5	25.1
Sodium (Na) & Potassium (K) as Na	69.2	26.6	26.4	26.0	23.8
Total Manganese (Mn)	0.10	0.12			
Total Iron (Fe)	1.05	2.90	5.0	1.7	5.6
Dissolved Iron	0.02	0.10			
Precipitated Iron	1.03	2.80			
Sulfate (SO_4)	9.0	21.0	97.3	92.8	61.3
Chloride (Cl)	50.5	31.7	46.0	40.0	33.0
Nitrate (NO3)	0.15	0.23	0.43	0.89	0.89
Fluoride (F)	0.1	0.10			
Total Suspended Matter	3.	11.8			
Total Dissolved Solids	382.	373.0	600.0	672.0	518.0
Total Hardness	235.7	233.0	410.0	391.0	379.0
Carbonate Hardness	235.7	233.0	303.0	301.0	302.0
Non-carbonate Hardness	0.0		107.0	90.0	72.0
Percent of Alkalies	39	20	12	12	12

*Al_2O_3

6. Owner: Harry Audsley, NE¼ NW¼ NW¼ sec. 30, T. 53 N., R. 21 W. Total depth of well 80 feet. Sampled May 9, 1957. Analyst: M E. Phillips.

7. Owner: W. Grover Pinney, NE¼ SW¼ sec. 6, T. 53 N., R. 21 W. Total depth of well 130 feet. Analyzed June 21, 1935 by R. T. Rolufs.

8. Owner: City of Norborne. Well number 1. Sampled July 7, 1954. Analyzed by the Missouri Division of Health.

9. Owner: City of Norborne. Well number 1. Sampled June 17, 1955. Analyzed by Missouri Division of Health.

10. Owner: City of Norborne. Well number 2. Sampled April 3, 1944. Analyzed by Missouri Division of Health.

CONSTITUENTS	IN PARTS PER MILLION		
	11	12	13
Turbidity	50.0	20.0	80.0
Odor		None	None
pH	6.9	7.0	6.9
Alkalinity ($CaCO_3$)	293.0	244.0	260.0
Phenolpthalein	0	0	0
Methyl Orange	293.0	244.0	260.0
Carbonate (CO_3)	0	0	0
Bicarbonate (HCO_3)	356.7	297.2	317.0
Silica (SiO_2)	16.0	20.0	20.0
Oxides (Al203, Fe203, TiO_2, etc.)			

CONSTITUENTS	IN PARTS PER MILLION		
	11	12	13
Calcium (Ca)	125.3	80.7	87.2
Magnesium (Mg)	27.0	18.9	21.0
Sodium (Na) & Potassium (K) as Na	16.8	12.6	15.6
Total Manganese (Mn)			
Total Iron (Fe)	7.0	7.0	7.5
Dissolved Iron			
Precipitated Iron			
Sulfate (SO_4)	110.3	35.8	43.0
Chloride (Cl)	39.3	13.4	14.0
Nitrate (NO3)	0.44	0.40	0.44
Fluoride (F)			0.3
Total Suspended Matter			
Total Dissolved Solids	660.0	392.0	428.0
Total Hardness	424.0	279.0	304.0
Carbonate Hardness	293.0	244.0	260.0
Non-carbonate Hardness	131.0	35.0	44.0
Percent of Alkalies	8	9	10

11. Owner: City of Norborne. Well number 2. Sampled July 10, 1956. Analyzed by Missouri Division of Health.

12. Owner: City of Carrollton. West well. Sampled March 2, 1951. Analyzed by Missouri Division of Health.

13. Owner: City of Carrollton. Well number 3. Sampled March 30, 1953. Analyzed by Missouri Division of Health.

DOMESTIC WELLS - Included in this category are wells developed for household or general farm use. Yields required from domestic wells vary but seldom exceed 15 gallons per minute. In some parts of Carroll County sands and gravels were not deposited in the glacial drift. There are also areas where the glacial drift cover is relatively thin or lacking. In such areas the possibility of developing wells is limited. Plate 1 shows the area most favorable for the development of domestic wells. Plate 3 is a contour map showing the elevation of bedrock above sea level. To determine probable drilling depths, the elevation of the bedrock should be subtracted from the surface elevation for each specific site. Plate 3 shows the locations of the test holes and the thickness of the glacial drift encountered.

IRRIGATION WELLS - Included in this category are all high yield wells whether used by cities, by industries, or for irrigation. Plate 2 shows the area most favorable for the development of irrigation wells. With

proper development, yields of 200-1000 gallons per minute may be obtained. Yields to be expected are contingent upon several factors:

(1) The thickness of the sand and gravel beds.
(2) The size and sorting of the sand and gravel.
(3) The manner of construction and materials used, such as proper well screen, gravel pack, etc.)
(4) Ability of the well driller to develop the full capacity of the water bearing sands.

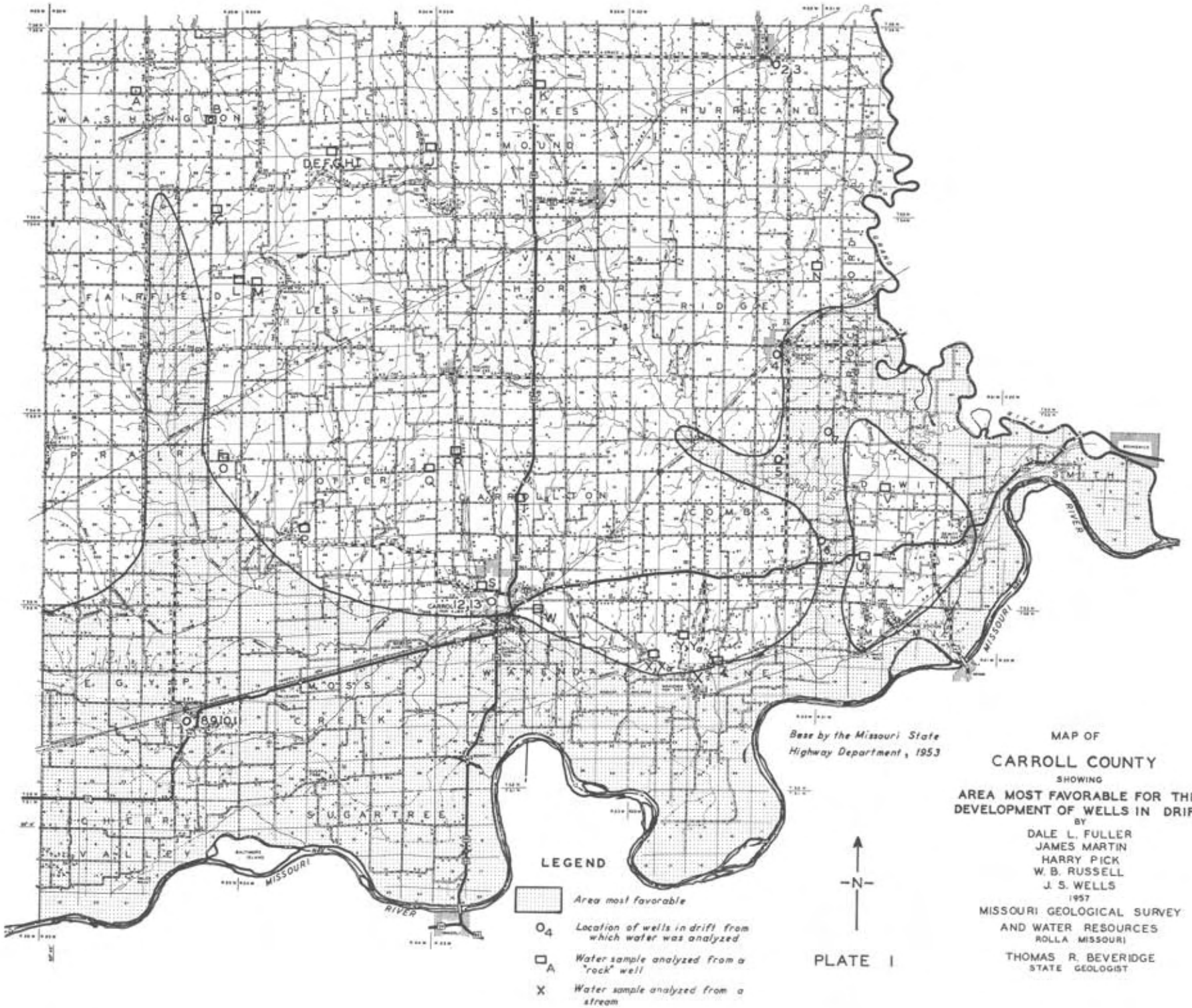
Continued successful production is contingent upon:

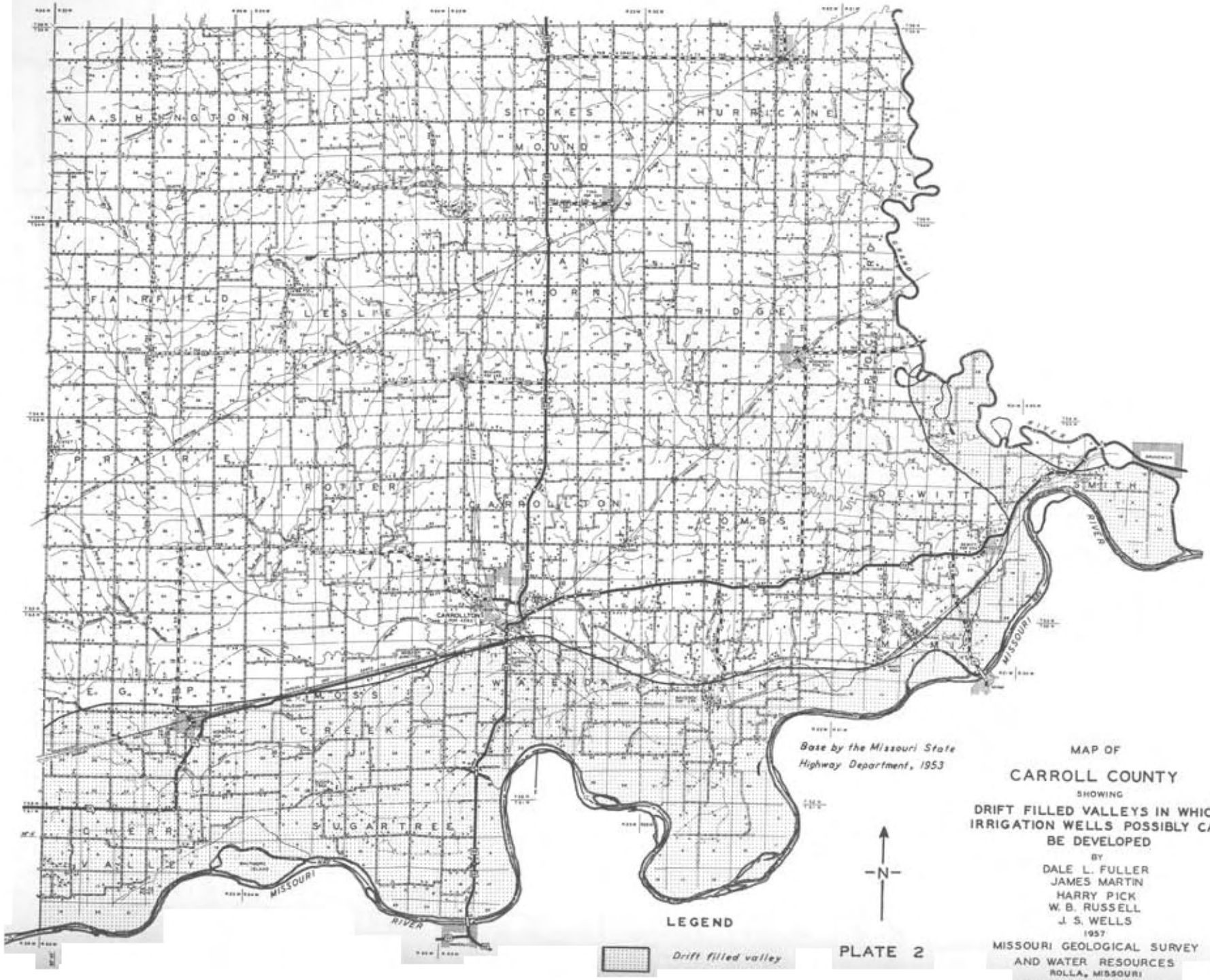
(1) Re-charge rate of the water-bearing horizons.
(2) Quality of the screen and materials used.
(3) Subsequent well treatment such as acidizing.
(4) Avoidance of over-pumpage.

SUMMARY

Approximately 100,000 acres of Carroll County are located within the area in which irrigation wells possibly can be developed. Approximately one-third of Carroll County's area is suitably located for obtaining water sufficient for domestic needs from the glacial drift.

Questions concerning water problems for a specific location should be sent to the Missouri Geological Survey and Water Resources, Box 250, Rolla Missouri 65401.


WASHINGTON
STOKES
HURRICANE
MOUND
DEFIANCE
FAIRFIELD
LESLIE
VAN HORN
RIDGE
PRAIRIE
CARROLLTON
COMBS
DWIGHT
SMITH
EGYPT
MOSS
CREEK
WAKENDA
SUGARTREE
CHERRY VALLEY
MISSOURI RIVER
MISSOURI RIVER
LEGEND
Area most favorable
Location of wells in drift from which water was analyzed
Water sample analyzed from a "rock" well
Water sample analyzed from a stream
Base by the Missouri State Highway Department, 1953
N
PLATE 1
MAP OF
CARROLL COUNTY
SHOWING
AREA MOST FAVORABLE FOR THE DEVELOPMENT OF WELLS IN DRIFT
BY
DALE L. FULLER
JAMES MARTIN
HARRY PICK
W. B. RUSSELL
J. S. WELLS
1957
MISSOURI GEOLOGICAL SURVEY
AND WATER RESOURCES
ROLLA MISSOURI
THOMAS R. BEVERIDGE
STATE GEOLOGIST



Base by the Missouri State Highway Department, 1953

MAP OF

CARROLL COUNTY

SHOWING

DRIFT FILLED VALLEYS IN WHICH IRRIGATION WELLS POSSIBLY CAN BE DEVELOPED

BY

DALE L. FULLER
JAMES MARTIN
HARRY PICK
W. B. RUSSELL
J. S. WELLS

1957

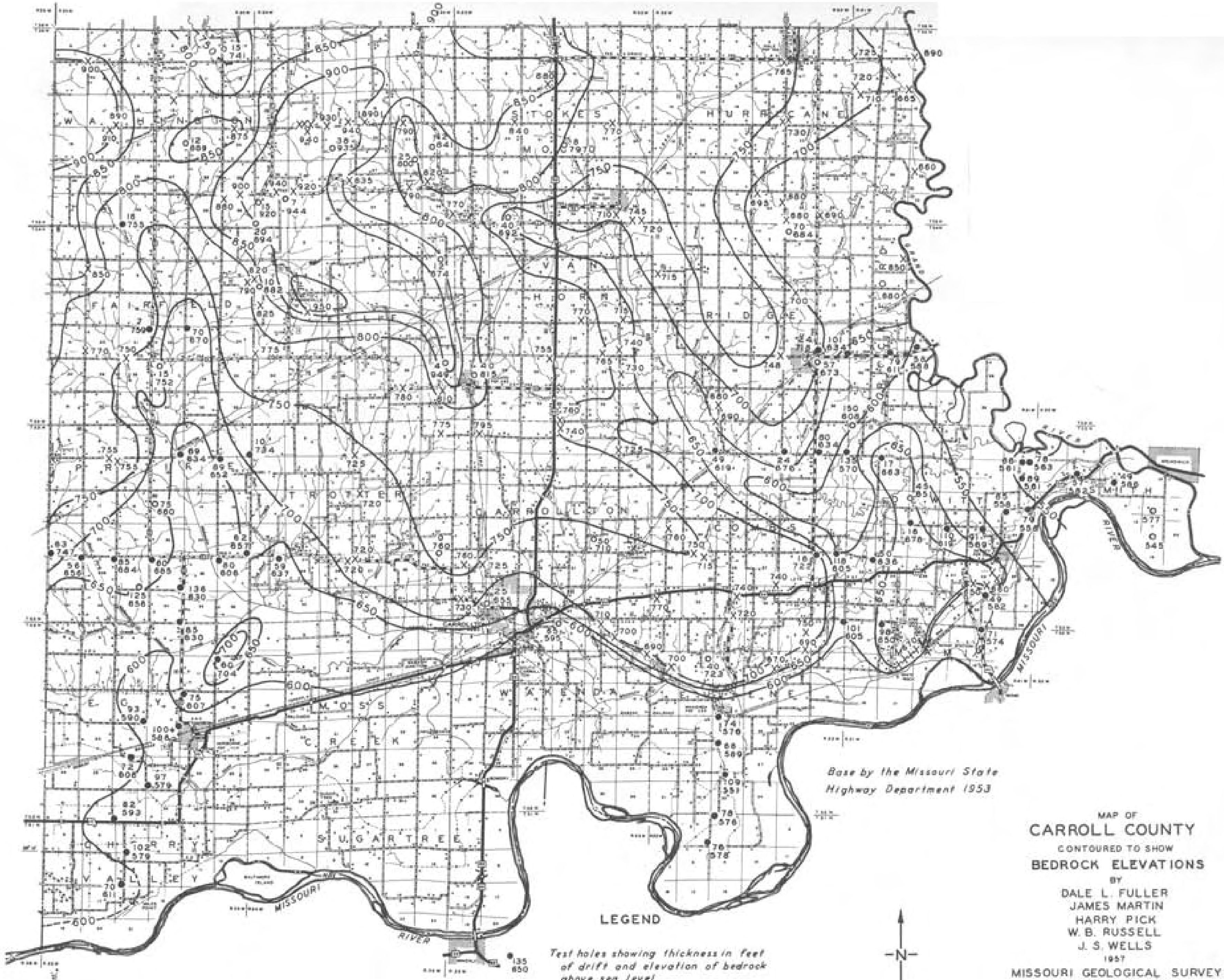
MISSOURI GEOLOGICAL SURVEY
AND WATER RESOURCES
ROLLA, MISSOURI

THOMAS R. BEVERIDGE
STATE GEOLOGIST

LEGEND

Drift filled valley

PLATE 2



LEGEND

- ● 135 / 850 — Test holes showing thickness in feet of drift and elevation of bedrock above sea level
- o — Water wells
- X — Bedrock outcrops
- 920 — Indicates outcrop elevation

-N-

MAP OF
CARROLL COUNTY
CONTOURED TO SHOW
BEDROCK ELEVATIONS
BY
DALE L. FULLER
JAMES MARTIN
HARRY PICK
W. B. RUSSELL
J. S. WELLS
1957
MISSOURI GEOLOGICAL SURVEY
AND WATER RESOURCES
ROLLA, MISSOURI
THOMAS R. BEVERIDGE
STATE GEOLOGIST

PLATE 3